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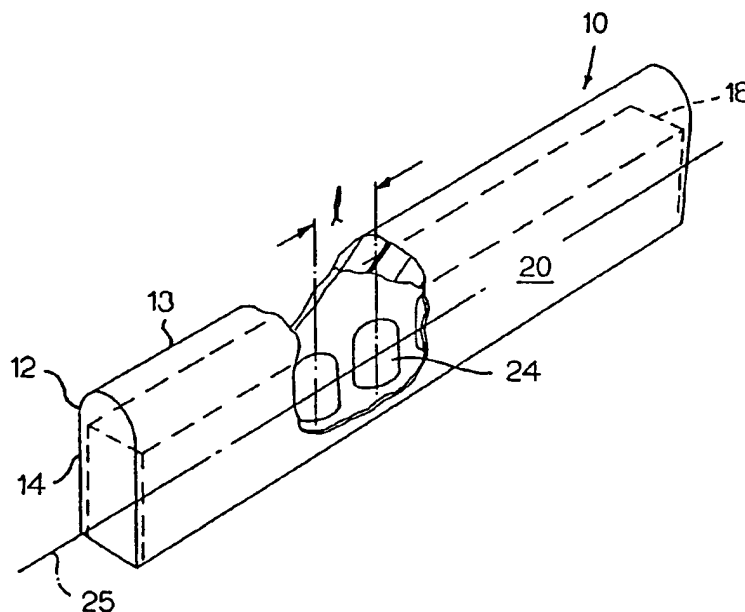
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- (71) Applicant: **ILIGHT TECHNOLOGIES, INC.** [US/US];
500 Skokie Blvd., Suite 575, Northbrook, IL 60062 (US).
- (72) Inventors: **CLEAVER, Mark, J.**; 100 Dupee Place, Wilmette, IL 60202 (US). **HULSE, George, Robert**; 1542 Dellwood Avenue, Cookeville, TN 38506 (US). **ERIKSSON, Eric, Olav**; 2608 Payne Street, Evanston, IL 60201 (US).
- (74) Agents: **SMITH, Vance, A.** et al.; Stites & Harbison, Suite 1800, 400 W. Market Street, Louisville, KY 40202 (US).
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(54) Title: **ILLUMINATION DEVICE FOR SIMULATION OF NEON LIGHTING**



(57) Abstract: An illumination device (10) for simulating neon lighting comprising a plurality of space point light sources (24) positioned adjacent a lateral light receiving surface (15) of a substantially rod-like waveguide (12) made of a material that preferentially scatters light entering the light receiving surface such that the light intensity pattern exiting a lateral light emitting surface (13) of the waveguide (12) has a substantially uniform light intensity pattern.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ILLUMINATION DEVICE FOR SIMULATION OF NEON LIGHTING

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BACKGROUND OF THE INVENTION

This application claims priority from Provisional Application 60/265,522 filed
10 January 31, 2001 entitled Simulated Neon Lighting for Illumination of Objects.

The present invention relates to illumination devices using optical waveguide
and, more particularly, to lighting devices for the simulation of neon lighting using
optical waveguides and high intensity low voltage light sources and ideally adapted
15 for signage and advertising uses.

Neon lighting, produced by the electrical stimulation of the electrons in the
low pressure neon gas filled glass tube, has been a main stay in advertising and for
outlining channel letters and building structures for many years. A characteristic of
20 neon lighting is that the tubing encompassing the gas has an even glow over its entire
length irrespective of the viewing angle. This characteristic makes neon lighting
adaptable for many advertising applications including script writing and designs
because the glass tubing can be fabricated into curved and twisted configurations
simulating script writing and intricate designs. The even glow of neon lighting being
25 typically devoid of hot spots allows for advertising without visual and unsightly
distractions. Thus, any illumination device that is developed to duplicate the effects

of neon lighting must also have axially even light distribution over its length and substantially even about its circumference. Equally important, such lighting devices must have a brightness that is at least comparable to neon lighting. Further, since neon lighting is a well established industry, a competitive lighting device must be

5 light in weight and have superior "handleability" characteristics in order to make inroads into the neon lighting market. Neon lighting is recognized as being fragile in nature. Because of the fragility and heavy weight primarily due to its supporting infrastructure, neon lighting is expensive to package and ship. Moreover, it is extremely awkward to initially handle, install, and/or replace neon lighting structures.

10 Any lighting device that can provide those previously enumerated positive characteristics of neon lighting while minimizing its size, weight, and handleability shortcomings will provide for a significant advance in the lighting technology.

U.S. Patent No 4,891, 896 issued on January 9, 1990 to Boren and assigned to

15 the Gulf Development Company is an example of many attempts to duplicate neon lighting. Like this attempt, most prior art neon simulations have resulted in structures difficult to fabricate and providing a little in the way of weight and handling benefits. The Boren patent exemplifies this by providing a plastic panel with essentially bas-relief lettering. The material comprising the lettering is transparent and coated with a

20 translucent material. The surrounding material is opaque. When the panel is back lit the lettering tends to glow with a neon-like intensity.

The more recent introduction of light weight and breakage resistant point light sources as exemplified by high intensity light emitting diodes ("LEDs") have shown

25 great promise to those interested in illumination devices that may simulate neon

lighting and have stimulated much effort in that direction. However, the twin attributes of neon lighting, uniformity and brightness, have proven to be difficult obstacles to hurdle as such attempts to simulate neon lighting have largely been stymied by the tradeoffs between light distribution to promote the uniformity and brightness. For example, U.S. Patent No. 4,976,057 issued December 11, 1990 to Bianchi describes a device that includes a transparent or translucent hollow plastic tubing which is mounted in juxtaposition to a sheet of material having light transmitting areas that are co-extensive to the tubing. The sheet is back lit by light sources such as LEDs which trace the configuration of the tubing. The tubing can be made into any shape including lettering. While the tubing may be lit by such arrangement, the light transfer efficiencies with such an arrangement is likely to result in a "glowing" tube having insufficient intensity to match that of neon lighting. The use of point light sources such as LEDs may provide intense light that rival or exceed neon lighting, but when arranged in arrays lack the uniformity needed and unfortunately provide alternate high and low intensity regions in the illuminated surfaces. Attempts to smooth out the light has resulted in lighting that has unacceptably low intensity levels.

It is therefore a paramount object of the present invention to provide for an energy efficient, virtually unbreakable alternative to neon lighting.

A further important object of the present invention is to provide for a lighting device that is safe to transport and economical to operate while providing all of the application virtues of neon lighting including uniformity and brightness.

Yet another object of the present invention is to provide for an alternative to

neon lighting that is environmentally friendly, requiring no neon gas, and running on significantly less electricity than its neon equivalent.

5 Still another important object is to provide for a neon equivalent that is easy to install without complex high voltage electrical installations.

 Yet a further object is to provide for a lighting device that can be placed in hostile environments such as in a freezer case without need for protective guards
10 against accidental contact by customers.

 These and other objects of the invention will become readily apparent and addressed through a reading of the discussion below and appended drawings.

15 **SUMMARY OF THE PRESENT INVENTION**

 The present invention utilizes a profiled rod of material having waveguide characteristics that preferentially scatters light entering one lateral surface ("light receiving surface") so that the resulting light intensity pattern emitted by another
20 lateral surface of the rod ("light emitting surface") is elongated along the length of the rod. A light source extends along and is positioned adjacent the light receiving surface and spaced from the light emitting surface a distance sufficient to create an elongated light intensity pattern with a major axis along the length of the rod and a minor axis that has a width that covers substantially the entire circumferential width
25 of the light emitting surface. In a preferred arrangement, the light source is a string

- of point light sources spaced a distance apart sufficient to permit the mapping of the light emitted by each point light source into the rod so as to create elongated and overlapping light intensity patterns along the light emitting surface and circumferentially about the surface so that the collective light intensity pattern is
- 5 perceived as being uniform over substantially the entire light emitting surface when being viewed from a normal head-on and side perspectives.

DESCRIPTION OF THE DRAWINGS

- 10 Figure 1 is an elevated perspective view of an illumination device of the present invention;

Figure 2 is perspective similar to that of Figure 1 with a portion broken away to show the interior;

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Figure 3 is an expanded side view of the illumination device as shown in Figure 1;

- Figure 3A is an enlarged wall segment of the illumination device shown in
- 20 Figure 3;

Figure 3B is an enlarged wall segment like that shown in Figure 3A with a variation in its structure;

Figures 4, 5, and 6 are respective front, side, and top elevation views of the

diodes connected to an electrical board as used in the present invention with Figure 5 also showing the configuration of the light emitting diodes and electrical board within the device;

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Figures 5A and 5B show side views of alternate configurations of the diodes and electrical board as positioned in the present invention;

Figures 7A and 7B show, respectively, a graph illustrating the light
10 distribution characteristics of a single point light source and a schematic of the device used to measure the same;

Figures 7C and 7D show, respectively, a graph illustrating the light
distribution characteristics of a single point light source mounted within a device
15 constructed in accordance with the present invention and a schematic of the device used to measure the same;

Figures 7E and 7F show, respectively, a Mercator-like top projection and a
side schematic of the illuminated lateral surface of the waveguide with overlapping
20 individual light distribution patterns;

Figure 8 is normalized pattern of the light distribution using an elliptically shaped LED assisting in creating the elongated light intensity pattern ;

Figures 9A, 9B, and 9C show several different internally positioned LEDs within the housing of the illumination device in accordance with the present invention;

5 Figures 10A and 10B show examples of different housing configurations in accordance with the present invention;

Figure 11 illustrates the illumination device of the present invention incorporating a plurality of lines of LEDs;

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Figure 12 shows one technique of supporting an illumination device made in accordance with present invention;

Figure 13 shows a technique of connecting individual lighting devices made in
15 accordance with the present invention;

Figure 14 shows a variation in the preferred embodiment in which the diodes are inclined within the housing;

20 Figure 15 shows still another variation in which the diodes are inverted within the housing;

Figure 16 shows an embodiment in which the LED is positioned within a channel defined in the body of the waveguide itself;

25

Figure 17 illustrates still another embodiment in which the light source is a

light source that itself is elongated and extends in a parallel relationship to the axis of the waveguide; and

5 Figure 18 representing a schematic of electrical circuitry incorporating LEDs for providing lighting sequences that may be used with the illumination device of the present invention.

10 **DETAILED DESCRIPTION OF THE INVENTION**

To provide the desired result, i.e., an illumination device that is an effective simulator of neon lighting, it is important that the proper materials be selected for the component parts and those parts appropriately and geometrically positioned so that

15 the resulting illumination device has an essentially uniform light intensity distribution pattern over the entire surface with the maximum obtainable brightness. To accomplish this, it is necessary to use a high intensity but dimensionally small light source together with an element that acts both as an optical waveguide and light scattering member, but permits light to exit laterally out of its surface (a "leaky

20 waveguide"). By placing the light source contiguous such a leaky waveguide in a specific manner so as to cause the waveguide to uniformly glow over its lateral surface while maximizing the amount of light exiting the surface, applicants are able to obtain an illumination device that rivals or surpasses the uniform glow of neon tubing. There are many light sources which have the necessary light intensity output

25 that is required but most are dimensionally too big to be practical, are fragile, or

consume too much energy. It has been further observed that the best light source

would likely be one with a small diameter that provided a uniform light output over an extended length. However, such light sources have not yet been developed to the technological state providing the intensity needed. Thus, applicants have determined
5 that the best available light source for the purpose here intended is a string or strings of contiguously mounted, essentially point light sources such as spaced apart high intensity LEDs.

The ultimate objective of the illumination device of the present invention is to
10 simulate an illuminated neon tube that glows with the proper intensity and uniformity over its length. Thus, applicants have determined that it is important that the leaky waveguide (used to simulate the neon tube) be comprised of a profiled rod of material having sufficient diffusivity that collectively with the other components of the invention visually eliminates any recognizable individual light distribution light
15 pattern that originates from a respective LED or other light source. As stated above, the profiled waveguide preferentially scatters light along its length but ultimately allows light to exit through its lateral surfaces. Such a waveguide provides a visible elongated or oval-like light pattern for each LED, brightest at the center and diminishing continuously out from the center along the major and minor axis of the
20 pattern. By spacing the LEDs a certain distance apart and each LED an appropriate distance from the exposed and lateral far side of the leaky waveguide, the light intensity distribution patterns on the surface of far side of the leaky waveguide are caused to overlap to such an extent that the variations in the patterns are evened out. This causes the collective light pattern on the lateral surface to appear to an observer
25 to have an uniform intensity along the length of the waveguide. Other components of

the illumination device of the present invention including, for example, the shape of the light sources may assist in establishing the required brightness and uniformity.

Structurally, the preferred embodiment of the present invention is portrayed in Figures 1-6 and shown generally as character numeral 10. The device 10 may be considered as having two major body components. The first component is a waveguide 12 having an exposed curved lateral surface 13 serving as the light emitting surface and a hidden lateral surface 15 (best seen in Figure 3) that serves as the light receiving surface. Waveguide 12 is the aforementioned leaky waveguide and surface 13 serves as the counterpart to the neon tube. That is, the light laterally entering the waveguide from a light source juxtaposed to the surface 15 is preferentially scattered so as to exit with a broad elongated light intensity distribution pattern out of surface 13. Visually, the waveguide 12, when not illuminated internally, has a milky appearance due to the uniform scattering of ambient light that enters the waveguide and that ultimately exits the lateral surface thereof. Applicants have found that acrylic material appropriately treated to scatter light and to have high impact resistant to be the preferred material for use in forming the waveguide components of the present invention. When shaped into the profiled rods, the rods take on the desired leaky waveguide characteristics. Moreover, such material is easily molded or extruded into rods having the desired shape for whatever illumination application may be desired, is extremely light in weight, and withstands rough shipping and handling. While acrylic material having the desired characteristics is commonly available, it can be obtained, for example, from AtoHaas, Philadelphia, Pennsylvania under order number DR66080 with added frosted characteristics. When shaped into a rod, such acrylic material is observed to have the

leaky waveguide characteristics desired. Other materials such as such as beaded

blasted acrylic or polycarbonate, or painted acrylic or polycarbonate provided with the desired preferential light scattering characteristics may be used as well for other applications.

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The second component of the present invention is a housing 14 positioned adjacent the surface 15 of the waveguide 12. Housing 14 comprises a pair of side walls 20, 22 abutting and downwardly extending from the surface 14 and defining an open ended channel 18 that extends substantially the length of waveguide 12. The housing 14 generally functions to house the light source and electrical accessories and to collect light not emitted directly into surface 15 and redirect it to the waveguide. In other words, the housing further serves to increase the light collection efficiency by directing by reflection the light incident upon the internal surfaces of the housing into the waveguide 12 and assist in the scattering of the light. From a viewer's perspective, it is desirable that the visual appearance of the housing 14 not be obtrusive with respect to the glowing surface 13 of the waveguide 12; thus, it is preferred that the outside surface of the housing be light absorbing and thus visually dark to an observer. Again, it is preferred that the housing also be made from an impact resistant acrylic material with the outer walls 20 and 22 having an outer regions formed from a dark pigmented, thus light absorbing, acrylic while the inner regions are made from a white pigmented, thus light reflecting, acrylic. The two regions are best viewed in Figure 3A show an enlarged segment of wall 20 in which the outer region 20a is the dark acrylic and the inner region 20b is the white acrylic. Such acrylic materials preferably are the same as used for the waveguide. While the waveguide 12 and housing 14 may be separately formed and then appropriately

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joined, it is preferred that the components be molded or extruded as a unit in long

sections with the channel 18 already formed.

An alternate wall structure is shown in Figure 3B in which the wall 20' has
5 three components, an outer dark region 20c, and intermediate light reflecting 20d, and
a transparent wall 20e which may be comprised of a scattering acrylic like the
waveguide. The outer and intermediate regions 20c and 20d could be dark and
white coatings painted on the wall 20' which itself may be comprised of a transparent
acrylic material or scattering acrylic. The light reflecting coatings can be of a color
10 matching the color of the LED if desired.

Although the above discussion sets forth a preferred construction of the
housing, it should be understood that in some applications the reflecting and
absorption characteristics may be provided by light reflecting and absorption paint or
15 tape. Additionally, where there is little concern about the visibility of the housing, it
may not be necessary to provide the light reflecting and/or absorption characteristics
to the outer surface of the side walls.

One the most beneficial attributes of the present invention is the ease that the
20 illumination device 10 can be bent to form designs or lettering. The channel 18
permits the device 10 can easily be deformed and bent into the desired shape. Once
the device 10 has been shaped, the LEDs 24 and the electrical connection board 26
are then inserted into the channel 18 and then the channel 18 be filled with a filler
compound. Thereafter the filler or potting compound is permitted to harden, thus
25 maintaining the positioning of the LEDs and circuit board 26. There are various

configurations of the LEDs 24 and board 26 that may be positioned within the channel

18. Examples of the configurations are shown in Figures 5A and 5B. A preferred configuration is that shown in Figure 5 because of the compact nature of the arrangement. In this arrangement, it is important, however, to observe the orientation of the circuit board 26 within channel 18 so that the board 26 extends along the length of channel to facilitate bending. The flexibility of the circuit board 26 with attached LEDs 24 permit this post design insertion into the channel 18 with the apex of the LED 24 essentially abutting the lower surface of the waveguide 12 (as illustrated in Figure 3). It is also important that the potting compound 30 used to fill channel 18 have the desired light transmitting characteristics and be effective in maintaining the positioning of both the LEDs and the board. The potting compound further serves to eliminate air gaps between the LEDs and the waveguide. It is preferable that the potting compound harden into an impact resistant material having an index of refraction essentially matching that of the housing 24a of the LEDs 24 to minimize Fresnel losses at the interface there between. The potting compound further adds strength to the structure by filling in the channel 18 and assists in reducing hot spots from forming on the lateral surface 13. Such potting compounds may be selected from commonly available clear varieties such as, for example, that obtainable from the Loctite Corporation, Rocky Hill, Connecticut under the brand name Durabond E-00CL. As is also seen in Figure 3, the bottom surface of the device 10 may be covered with a light reflecting surface 32 which may be, for example, a white potting compound or paint and this optionally covered with a light absorbing material 34. In those instances where the selected LEDs 24 have a certain color the light reflecting surface may also be selected to have a matching or substantially the same color. To

take advantage of ambient light certain dyes may be added to the acrylic material so

that the device 10 exhibits some readily distinguishable coloring upon viewing.

The intensity of the point light sources preferably used by the present invention are typically sufficient to provide the requisite brightness. It bears repeating that the quintessentially feature of the present invention, however, is the careful spreading or distribution of the individual light patterns of the point light sources such that the light patterns are preferentially expanded along the light emitting surface and form an oblong or oval-like light intensity pattern. Equally important is that the minor axis of the oval-like light intensity pattern extends substantially the entire circumferential width of the curved light emitting surface. The preferential spreading of each of the light intensity patterns along the waveguide also permits an the overlapping of the individual light patterns. This in turn enables the present invention to provide an observed uniform collective light pattern along and over the entire light emitting surface.

There are various parameters that have an impact on both the brightness and uniformity of the light intensity pattern emitted by the surface 13 of the waveguide 12. Among the most important are the scattering characteristics of the waveguide material, the spacing "l" between LEDs 24 as shown in Figure 2, the lensing effect of the LED housing and internal optics where the light emitting portion of the LED resides, the shape and structure of the housing, and the distance "d" (shown in Figure 3) from the apex of the LED housing 24a to the apex point 12a on the lateral surface 13. To promote uniformity of the light intensity distribution pattern on the surface of the waveguide is that the line of LEDs 24 must be positioned a predetermined

distance "d" from apex point 12a of the waveguide. Positioning the LEDs 24 too close to the surface will cause a 'hot spot', i.e., a region of higher light intensity to locally appear on the surface 12a of the waveguide and spoil the quality of the uniform glow. Placing in too far from surface 12a will clearly and undesirably diminish the overall light intensity emanating from the waveguide 12 and may also prevent the minor axis of the oblong or elliptical-like pattern from extending over the circumferential width of the light emitting surface. As an example only, it has been determined that when the curved surface has a radius of curvature of about 3/16 (about 4.76 mm), the device 10 (shown in Figure3) has a height "h" of about 31 mm and a width "w" of about 9.5 mm, and the LEDs have a candle power of about 280 mcd and are spaced apart about 12mm, the distance "d" should be about 17.75 to 17.80 mm. It should be understood, however, that while the above describes a preferred waveguide structure that resembles neon tubing dimensionally, other and different shapes of waveguides may be used yet still providing the desired uniform glow.

To better understand the principal under which the present invention operates, reference is now made to Figures 7A-7F as examples of the changes of the light intensity and spread of the light pattern comparing light intensity and spread of a typical diode to that of an illuminating device constructed in accordance with the present invention. A single LED or point light source provides a narrow light intensity pattern 54 as graphically portrayed by Figure 7A. Such a graph can be generated by using a photocell type of device 50 portrayed in Figure 7B and progressively measuring the light intensity at various angles from the center line 51. This light pattern 54 should be contrasted to the one in Figure 7C in which the pattern

56 is considerably broader with a concomitant reduction in the intensity along the center line 51. Figure 7C represents the broad pattern emitted by the lateral surface 13 of the waveguide 12 constructed in accordance with the present invention. As stated above, it is important that the distance "d" and the LED spaced apart distance "l" be such that the oval-like intensity patterns of the individual LEDs overlap as portrayed in the schematic representation of Figure 7E and the projection depicted in Figure 7C schematically represents a plurality of LEDs 24 providing an broadened overlapping elliptical-like light intensity patterns 31 on the lateral surface 13 of the waveguide 12. Figure 7E is top view using a Mercator-like projection of the light pattern areas 24 on the lateral surface. 13. The minor axis of the light intensity patterns 31 are represented by dashed lines 33. As stated above, for any given dimension of the waveguide and spacing of the point light sources, it is important that the distance "d" be appropriately set so distance so that the minor axis of the light intensity distribution pattern extends substantially the entire circumferential width of the curved lateral light emitting surface 13. For purposes of this disclosure the light intensity distribution pattern can be defined as the visible area of the light pattern extending out from the center region of the area that is visible discernible by an observer.

20 To further assist in the preferential diffusion and scattering of the light intensity pattern, applicant has further determined that the use of oval shaped LEDs as shown in Figure 6 are helpful. The best effect is obtained when the oval shaped LEDs are positioned so that the major axis of the elliptically shaped light patterns seen in top elevation view is directed along the long axis of the waveguide 12. The characteristic light pattern of an oval LED is shown in Figure 8 depicting graphically

normalized light intensity along the major and minor axis. As can be seen, the oval

LED tends to direct light along its major axis illustrated by the curve 36.

The light weight and ruggedness of the illumination device 10 of the present invention lends itself to ready mounting to almost any surface and by a variety of mounting techniques. For example, as illustrated in Figure 12, an extended length of the device 10 could be mounted in curtain rod fashion to a wall board 44 through the use of a bracket hook 40 and fastener 42. Moreover, successive lengths of the device 10 can be easily juxtaposed such as, for example, depicted in Figure 13 where dowels 46 of matching refractive indices with the material of the waveguides 12, 12' are inserted in complimentary openings in the respective ends. Other fastening techniques may be employed including gluing of the various lengths together at the ends thereof. In some instances where the lengths when appropriately supported, the ends of the lengths may merely be placed in a juxtaposed touching position. Thus, as can easily be understood, illumination devices 10 of an indeterminate length can easily be installed and supported.

Figures 9A, 9B, and 9C represent in schematic form but a few of the alternate constructions in which the LEDs 24 are appropriately spaced from the apex point of the waveguide. Figure 9A depicts a light scattering spacer member 48 between the waveguide 12 and the LED 24. Such spacer 48 could be fabricated from the same material as the waveguide 12, e.g., a high impact resistant acrylic material. Figure 9B represents a construction in which the channel 18 is dimensioned so that the LED abuts an inner face of the channel and defines a space 50 between the apex of the LED housing and the waveguide 12. Figure 3 shows the use of a transparent potting

compound that fills the space between the LED 24 and waveguide 12. The compound could easily be introduced into the channel 18 after the LED 24 and circuit board 26 are placed therein.

5 Figures 10A and 10B illustrate that the configuration of the illumination device 10 including the waveguide and/or housing could be changed as determined by the application to which the illumination device may be applied. Figure 10A depicts parallel side walls 20, 22 that merge into sharply diverging side walls 23, 25 of the waveguide 12 while Figure 10B illustrated as structure in which the walls 20, 22
10 diverge gradually and blend into the diverging side walls 23, 25 of the waveguide 12. Figure 11 depicts further variations to the illumination device 10 where multiple strings of LEDs may be used in place of the single one discussed above. The various other elements including the reflective and absorption layers are not shown to maintain clarity.

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 Although it is preferred that the LEDs 24 be oriented in an upright position as depicted in Figure 3 in order to provide the most efficient light intensity along the light pattern, other positioning arrangements may be used. One example is shown in Figure 14 where the positioning of the LEDs is tilted so that central axis 50' of the
20 LEDs is placed at some predetermined angle X to the normal orientation 50 of the central LED axis to the longitudinal axis 52. Figure 15 shows the LED 24 positioned with the apex positioned downwardly (vertically positioned or tilted) with respect to the axial length of the waveguide. The light collection of the various reflective surfaces direct the light from the LED 24 to the waveguide for the scattering
25 in the same manner as described above.

Figure 16 depicts still another structure where the housing 110 of the LED 120 or point light source is incorporated directly in the body of the waveguide 100 with reflective and absorption layers not shown to maintain clarity.

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Technology is being developed where a light source may be fabricated in elongated or rope form from, for example, sheets of electro-luminescing material that has sufficient light intensity to be juxtaposed to a leaky waveguide in place of the strings of LEDs. Figure 17 illustrates that such a construction of an illumination
10 device 140 showing an elongated light source 170 extending in a parallel relationship with the longitudinal axis of the waveguide 150 within the housing 160.

The thin and flexible circuit board 26 can be obtained from various sources such, as, for example, Flexible Circuit Technologies, Saint Paul Minnesota. The
15 nature of the electrical connection and the circuitry on the board 26 depend upon the illumination sequence desired. While the circuitry is not part of the invention, it should be observed that the considerable sequence variety is permitted by the nature of the structure of the present invention. That is, the light weight, resistance to the rigors of packaging, handling, shipping, and installation, and the minimal heating
20 aspects of the illumination device permit essentially endless possibilities for lighting and color sequences. The circuit board, may for example, be provided with various electrical components that permit flashing or fading of the light sources in timed sequences and give the effect of movement. Various light source colors can be used and flashed/faded in almost any combination. If the LEDs are interlaced with
25 different colors, then a striping effect can be obtained. Figure 18 illustrates

of LEDs 230 are shown connected in series to a remote power source 232 and to a NPN transistor 234 in turned connected to a programmable controller 236. The LEDs 230 may be of the same color or in color groupings as desired. A second set of LEDs 240 (and additional sets of LEDs) similarly connected to the power source 232, NPN transistor 242, and controller 236 may be separately grouped or alternated with LEDs 230 as desired. Using the former grouping, the controller 236 could be programmed to cause the transistors to go on or off, thus causing the first group and then succeeding groups of LEDs to pulse or flash, simulating motion. Should each of the groups mounted in a device form a sequence of words, for example, "drink cola", the words could be flashed in sequence. If the LEDs of various groups were alternated in position, the resulting grouping could form a multi-color striping pattern.

From the discussion above, it may now be appreciated that the illumination device of the present invention is rugged and resists breakage that normally would be expected for neon lighting counterparts in shipping and handling. The illumination sources, preferably solid state lighting devices such as LEDs, uses far less electrical energy and remains relative cool to the touch. This allows the illumination device of the present invention to be used in places where the heat generated by neon lighting precludes its use. Moreover, the light weight of the illumination device facilitates mounting on support structures that could not support the relative heavy weight of neon lighting, and its required accessories including the high voltage infrastructure. Finally, the illumination device is flexible in its use, allowing a tremendous variety of lighting techniques very difficult to obtain in neon lighting without substantial expense. Other advantages and uses of the present invention will be clearly obvious

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to those skilled in the art upon a reading of the disclosure herein and are intended to

be covered by the scope of the claims set forth below.

1. An illumination device for simulating neon lighting comprising
a substantially rod-like waveguide having a predetermined length with a
5 lateral light receiving surface and a lateral curved light emitting surface having a
predetermined circumferential width, said waveguide being comprised of a material
that preferentially scatters light entering said light receiving surface such that a light
intensity pattern exiting said light emitting surface has a major axis extending along
said predetermined length and
10 an elongated light source extending along and positioned adjacent said light
receiving surface and spaced from said light emitting surface a distance sufficient to
cause said light intensity pattern to have a minor axis with a length extending
substantially the entire circumferential width of said light emitting surface.
- 15 2. The illumination device of claim 1 in which said elongated light source
is a multiplicity of spaced point light sources arranged in a line extending
substantially along said light receiving surface, said point light sources are spaced
from one another a distance sufficient to cause the light intensity pattern of each light
source to overlap and form a collective light intensity pattern that appears
20 substantially uniform along said length of said light emitting surface.
3. The illumination device of claim 2 in which said point light sources are
light emitting diodes.

4. The illumination device of claim 3 in which said light emitting diodes have an oval shape with a major axis extending in a direction along said line.
5. The illumination device of claim 1 further including a housing in which said light source is positioned, said housing extending along said light receiving surface and having a pair of side walls each with an interior light reflecting surface and an exterior light absorbing surface and an electric connecting member positioned within said housing and adapted to connect said light source to a remote power source.
6. The illumination device of claim 5 in which said housing is adapted to be bent into a non-linear shape and said electric connecting member extends along the length of said housing and is sufficiently flexible so as to be bent to conform to the non-linear shape of said housing.
7. The illumination device of claim 6 in which said electric connecting member is a flexible ribbon.
8. The illumination device of claim 5 including a light transmitting material filling an interior space of said housing to maintain positioning of said light source and electric connecting member within said housing.
9. The illumination device of claim 8 in which said light transmitting material is transparent.

10. The illumination device of claim 8 in which said light transmitting material has light scattering characteristics.

11. The illumination device of claim 8 in which said light source are a plurality of light emitting diodes and said light transmitting material has an index of refraction essentially matching the index of refraction of said light emitting diodes.

12. The illumination device of claim 8 in which said light transmitting material forms a bottom wall extending along the length of said housing, said bottom wall having a light reflecting bottom surface for reflecting light incident thereon into said wave guide.

13. The illumination device of claim 8 in which said light transmitting material is a heat conductor.

15

14. The illumination device of claim 2 including a light transmitting spacer member positioned between said light source and said light receiving surface and in a substantially abutting relationship with said light source.

20 15. The illumination device of claim 5 in which said waveguide and said housing are integral and comprised of a impact resistant acrylic.

16. The illumination device of claim 3 wherein the light emitting diodes have housings aligned in an essentially upright position with an apex of each housing juxtaposed to said light receiving surface of said waveguide.

25

17. The illumination device of claim 3 wherein the light emitting diodes have housings tilted with respect to the length of the waveguide.

5 18. The illumination device of claim 3 wherein the light emitting diodes have housings arranged in an inverted positions with respect to said light receiving surface

19. An illumination device comprising

10 (a) an optical waveguide having a predetermined length and a lateral surface and defining a housing extending substantially the entire predetermined length, said waveguide being fabricated of a material capable of being flexed;

 (b) a string of spaced point light sources positioned within said housing and extending along the length thereof;

15 (c) an elongated circuit board positioned within said housing and electrically connected to said point light sources.

20. The illumination device of claim 19 wherein said point light sources are LEDs.

20

21. The illumination device of claim 20 in which said material preferentially scatters light entering said waveguide along its predetermined length.

material filling said interior space to maintain positioning of said LEDs and said circuit board within said housing.

5 23. An illumination device for simulating neon lighting comprising
 a first light transmitting member of a predetermined length comprised
 of waveguide material having a substantially curved front surface, said waveguide
 material preferentially scattering light entering a first lateral surface so that light
 emitted by a second lateral surface has a light distribution pattern skewed along said
10 length with light scattering characteristics;

 a housing adjacent said waveguide with spaced side walls abutting said
 first lateral surface and defining a volume extending along said predetermined length
 of said first light transmitting member, said side walls provided with a light reflecting
 interior surface and a light absorbing exterior surface;

15 a multiplicity of spaced point light sources housed within said volume
 and extending along said predetermined length, said spaced light sources positioned a
 distance from said second lateral surface so as to minimize the viewing of localized
 regions of high light intensity within said light distribution pattern. to have uniform
 along distribution providing transmission of a uniform light distribution pattern; and
20 an electrical source connecting member positioned within said volume and
 connected to said point light sources.

 24. The illumination device of claim 23 in which interior surfaces of said
 side walls are covered with a light reflecting material and exterior surfaces are
25 covered with a light absorbing material.

25. The illumination device of claim 23 in which said side walls are essentially parallel to each other.

5 26. The illumination device of claim 25 including a spacer member made of transparent material positioned and filling a portion of the volume between said point light sources and said member.

27. The illumination device of claim 23 in which said point light sources
10 are LEDs.

28. The illumination device of claim 27 in which said electrical member is connected to a processor programmed to cause said LEDs to flash independently.

15 29. The illumination device of claim 28 in which the LEDs flash in a timed sequence.

30. The illumination device of claim 28 in which said LEDs are flashed in successive groups along the length of the first string thereby simulating movement.

20

31. The illumination device of claim 27 including a multiplicity of LEDs mounted in a second string positioned within said volume and extending in the direction of elongation of said housing, said second string connected with said electrical member so as to be independently energized.

25

string are alternatively positioned along the length of said housing with said LEDs of said second string.

5 33. The illumination device of claim 31 in which said LEDs of said first string emit a different color of light from the LEDs of said second string.

 34. A method of making an illumination device capable of simulating neon lighting comprising the steps of

10 forming a rod with a predetermined length and a pair of lateral surfaces from material having optical waveguide properties with preferential light scattering characteristics such that light entering a first of said lateral surfaces is caused to form an elliptically shaped light intensity pattern that has a major axis in a direction substantially parallel to said predetermined length;

15 placing a housing having a pair of spaced side walls defining a volume in a connected relationship with said first lateral surface;

 bending said rod and housing into a desired shaped;

 positioning a plurality of spaced point light sources connected to a flexible electrical connecting member within said volume between said side walls; and

20 filling said volume with potting material transmitting light.

35. The method of claim 34 wherein said rod and housing are formed as an integral unit.

36. The method of claim 34 wherein said side walls have interior surfaces that are light reflecting.

37. The method of claim 34 in which said point light sources are LEDs.

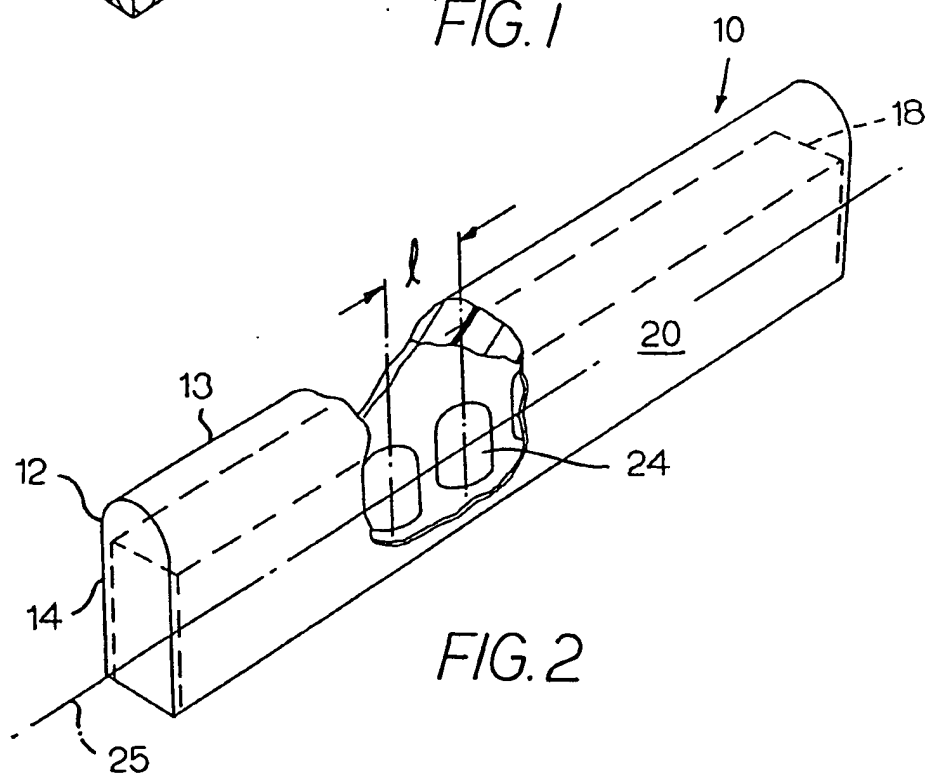
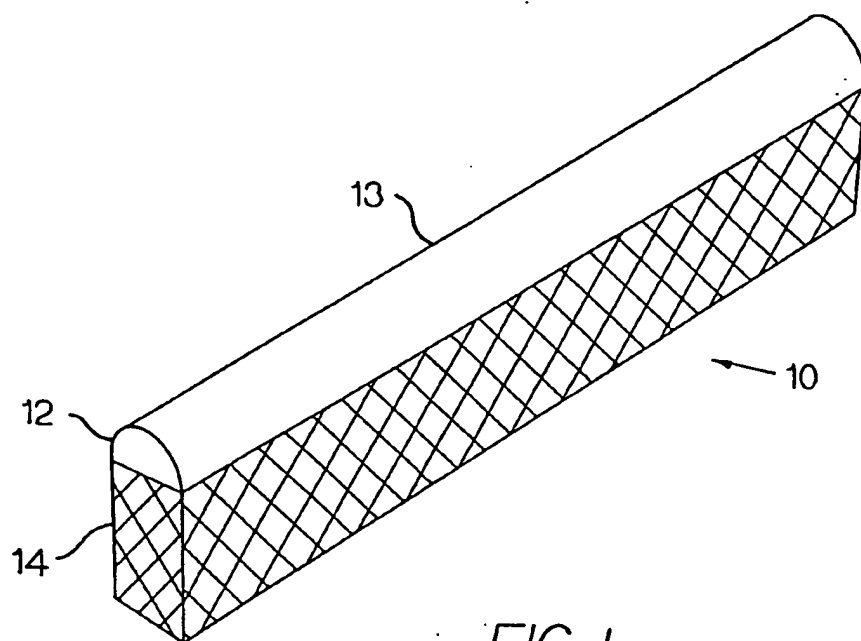
5

38. The method of claim 37 in which said LEDs have transparent housings and said potting compound has an index of refraction essentially matching an index of refraction of said transparent housings.

10 38. The method of claim 37 in which said LEDs have tinted housings.

40. The method of claim 34 wherein said side walls have exterior surfaces that are light absorbing.

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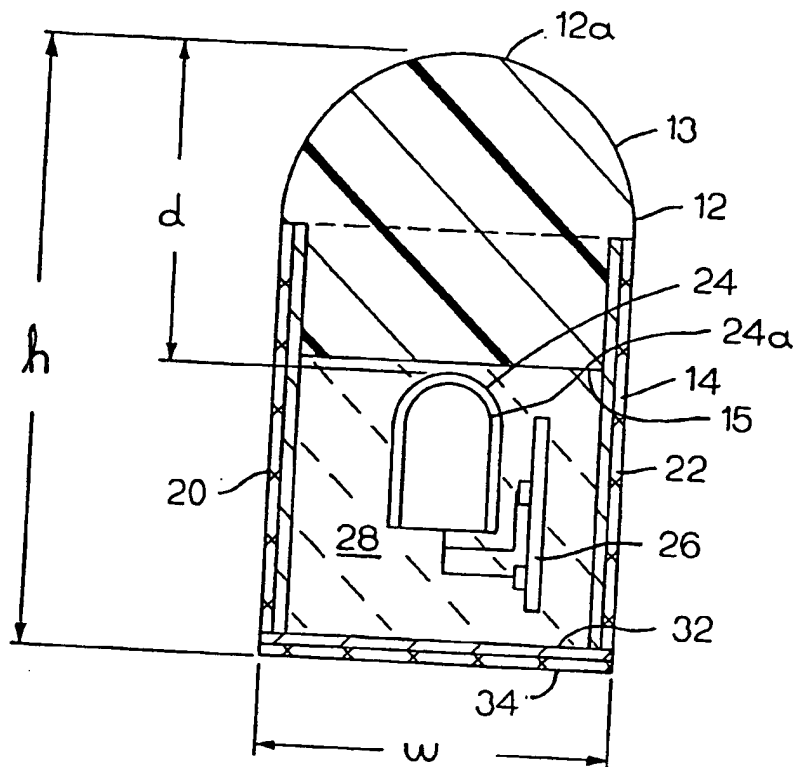


FIG. 3

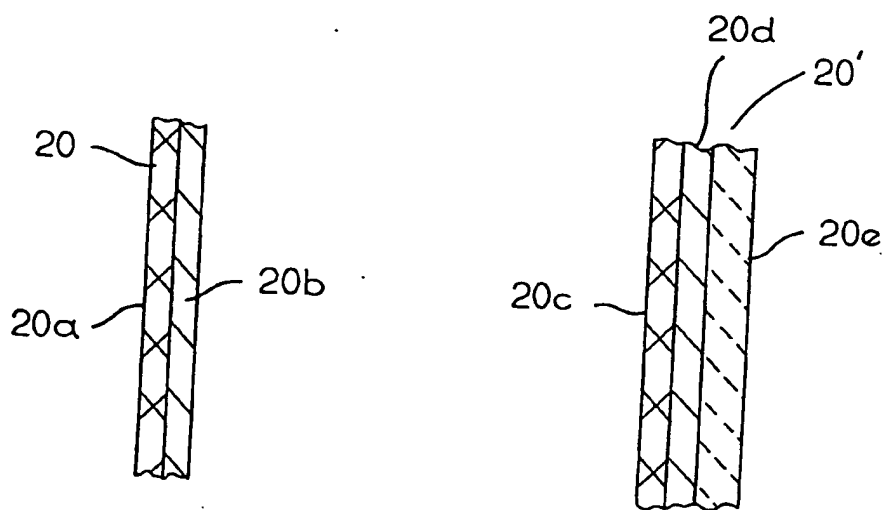


FIG. 3A

FIG. 3B

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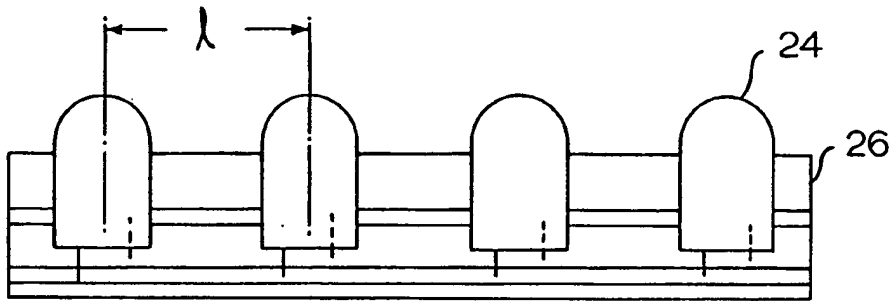


FIG. 4

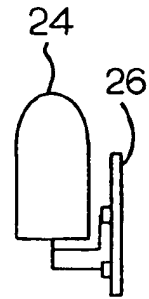


FIG. 5

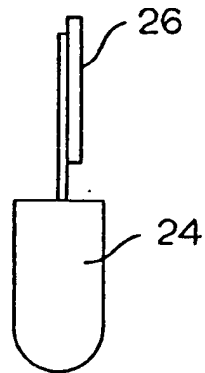


FIG. 5A

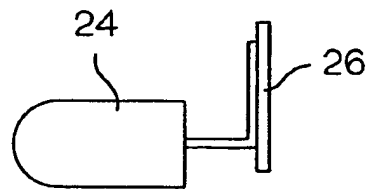


FIG. 5B

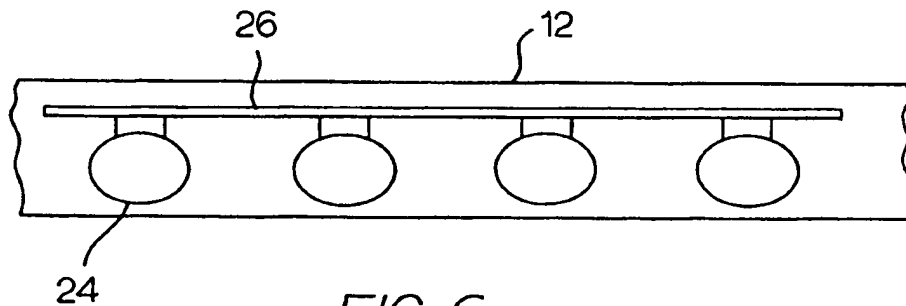


FIG. 6

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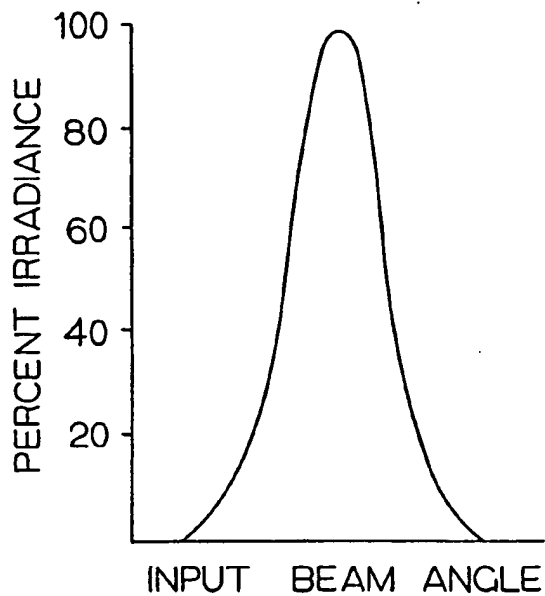


FIG. 7A

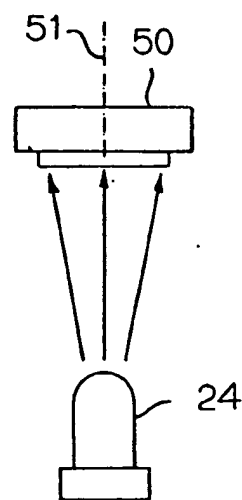


FIG. 7B

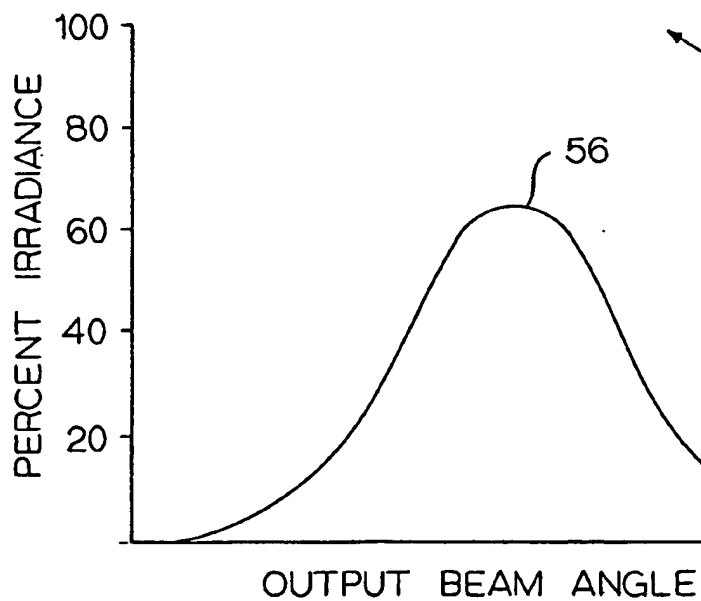


FIG. 7C

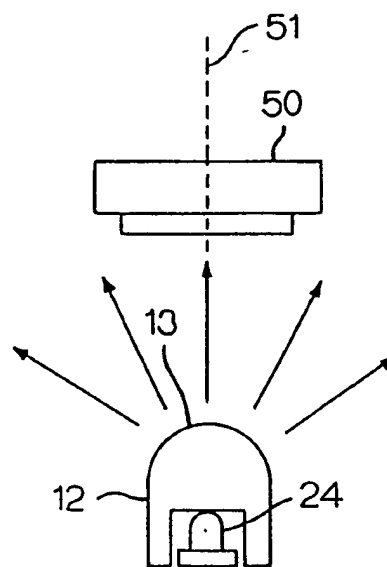


FIG. 7D

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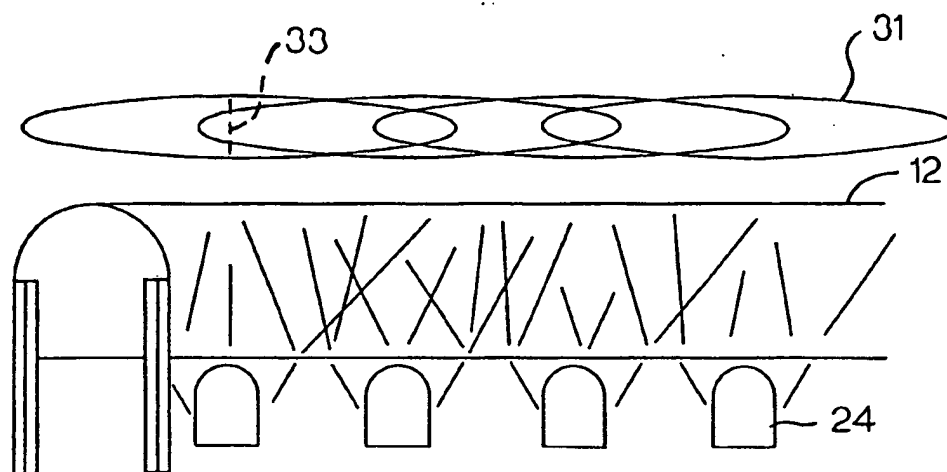


FIG. 7E

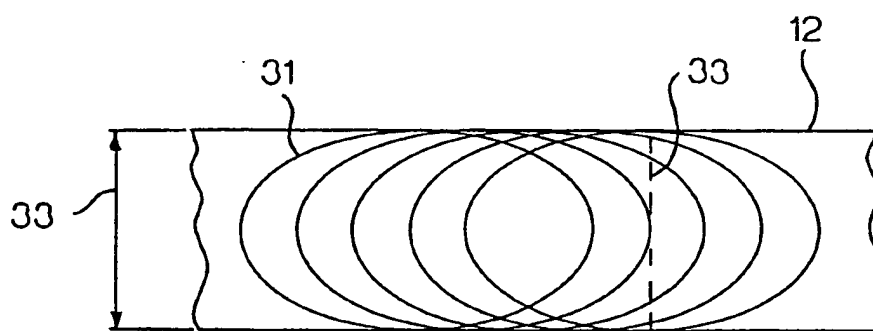


FIG. 7F

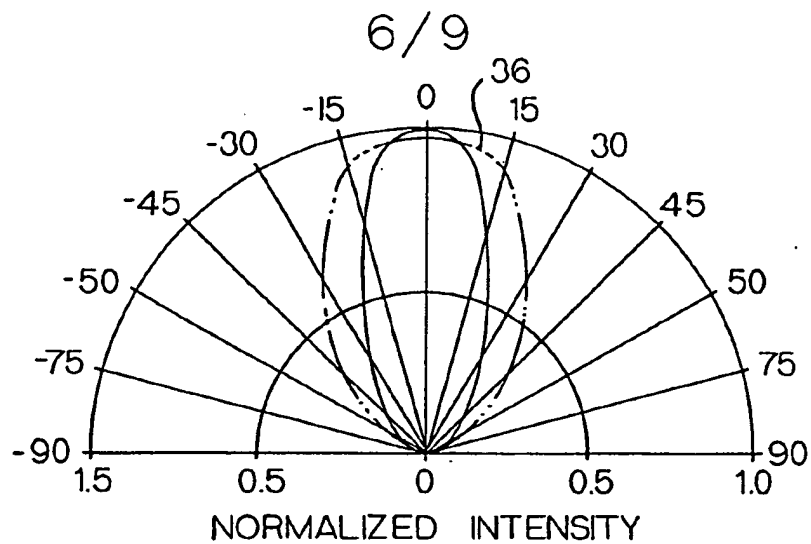


FIG. 8

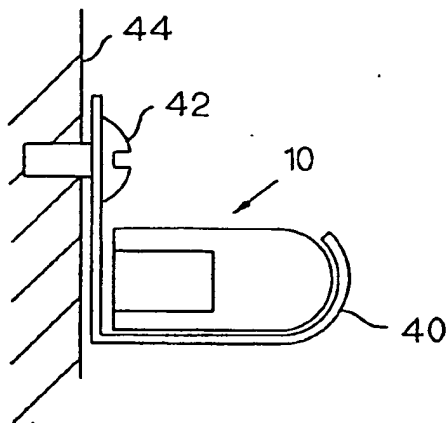


FIG. 12

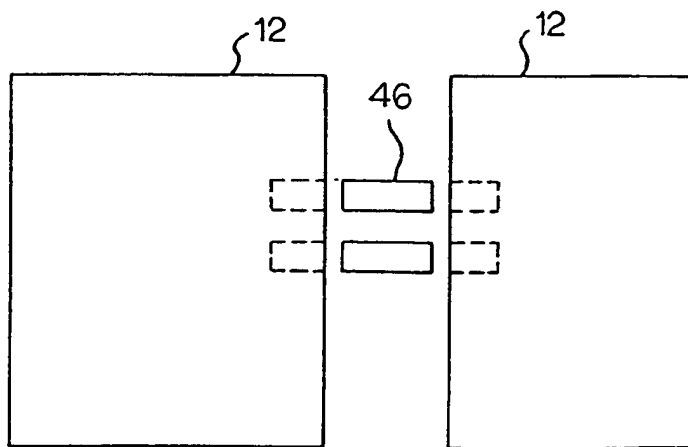


FIG. 13

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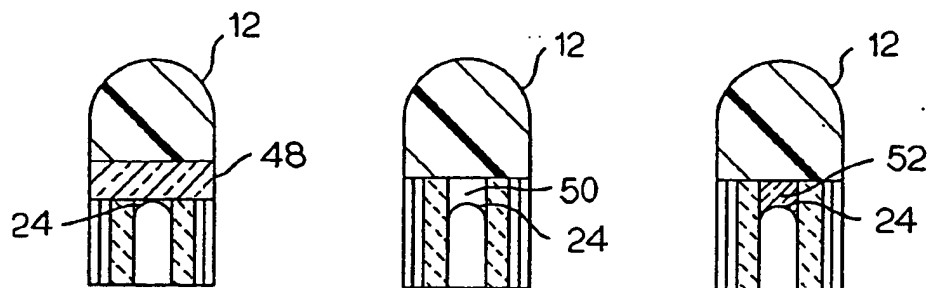


FIG. 9A

FIG. 9B

FIG. 9C

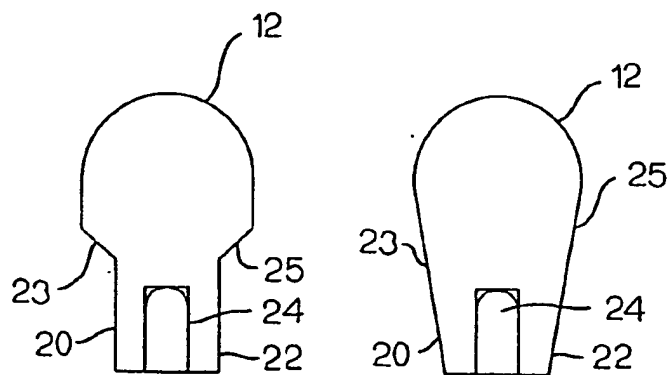


FIG. 10A

FIG. 10B

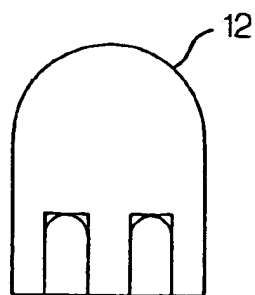
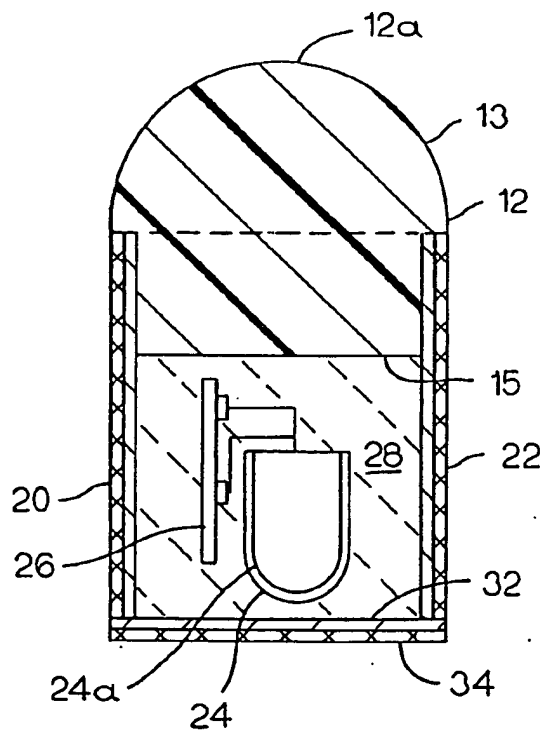
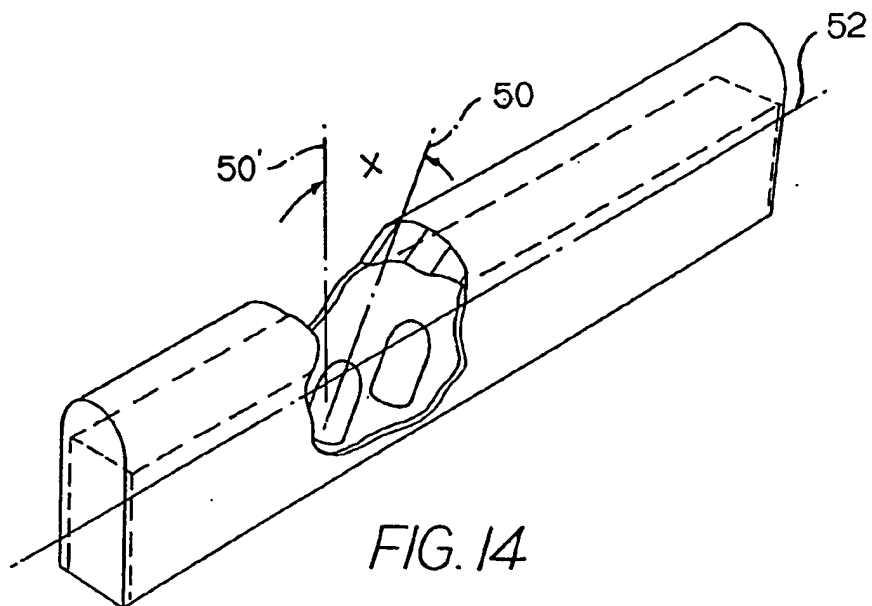
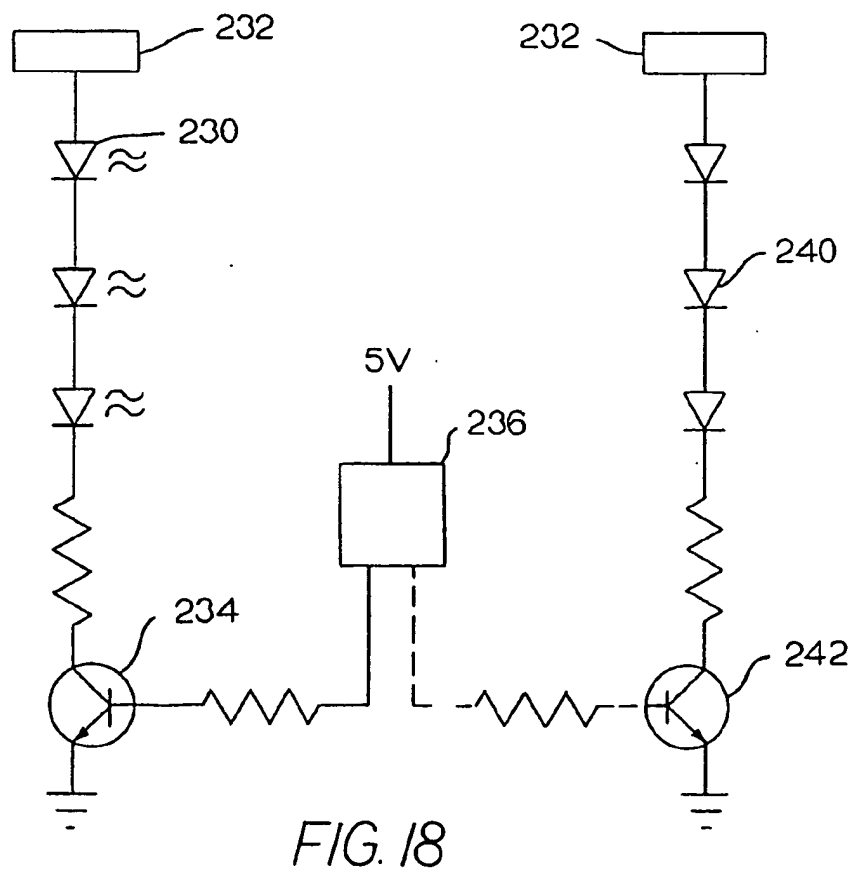
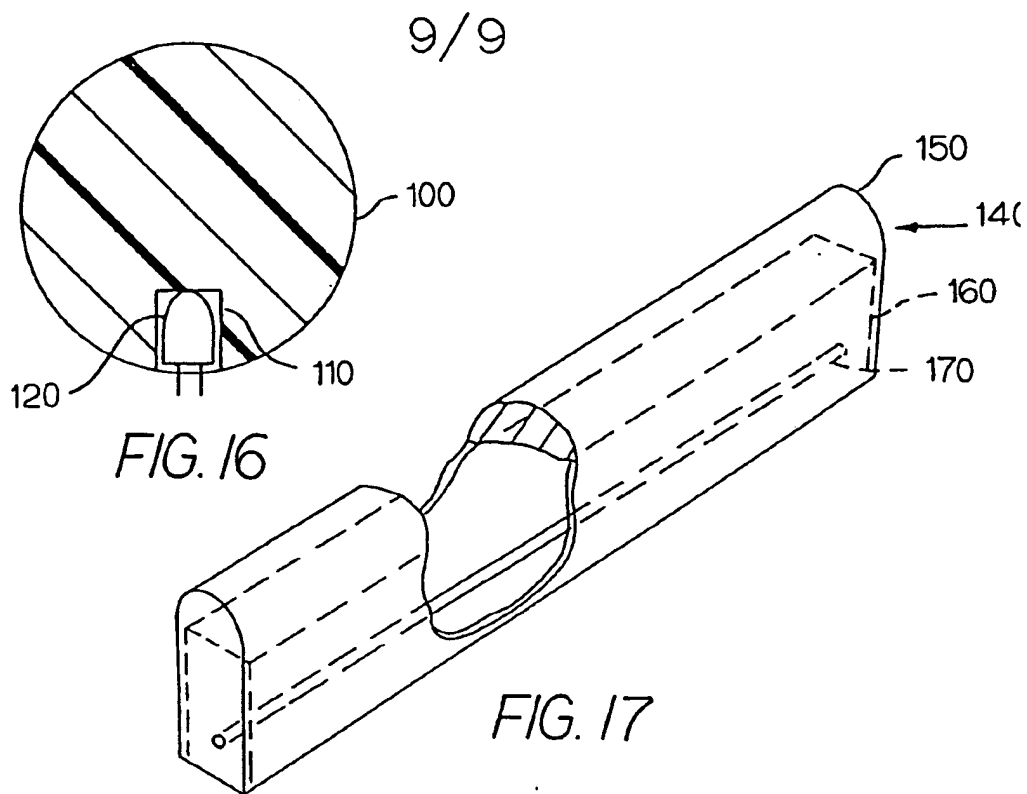


FIG. 11

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/47629

| A. CLASSIFICATION OF SUBJECT MATTER IPC(7) : F21S 3/00 US Cl. : 362/219, 235, 249 AND 800 According to International Patent Classification (IPC) or to both national classification and IPC | | |
|---|--|---|
| B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 362/219, 235, 249 and 800 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) | | |
| C. DOCUMENTS CONSIDERED TO BE RELEVANT | | |
| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| X | US 4,607,317 A (LIN) 19 August 1986 (19.08.1986), whole document | 1-40 |
| X | US 5,057,981 A (BOWEN et al) 15 October 1991 (25.10.1991), whole document | 1-40 |
| X,P | US 6,193,385 B1 (MAKI et al) 27 February 2001 (27.02.2001), whole document | 1-40 |
| A | US 6,158,882 A (BISCHOFF, Jr.) 12 Decemberr 2000 (12.12.2000), whole document | 1-40 |
| A | US 5,964,518 A (SHEN) 12 October 1999 (12.10.1999), whole document | 1-40 |
| <input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex. | | |
| * Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family | | |
| Date of the actual completion of the international search 18 MARCH 2002 | | Date of mailing of the international search report 11 APR 2002 |
| Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230 | | Authorized officer THOMAS M. SEMBER Telephone No. (703)-308-1938 <i>Deborah Perry-Leeper</i> Paralegal Specialist Technology Center 2800 |